A VARIETY OF MAIZE FROM THE RIO LOA

EDGAR ANDERSON

Fellow of the Guggenheim Foundation
Geneticist to the Missouri Botanical Garden (on leave)

In our collections of maize, two ears procured by Carl and Jonathan Sauer at a remote oasis on the Rio Loa in northern Chile are of particular interest. They are in various ways more like prehistoric Peruvian maize than anything else in our collections. In several peculiar characters they also bear a close resemblance to certain Oriental varieties. These facts reopen the entire problem of pre-Columbian contacts between the New World and the Orient. The actual facts concerning these remarkable plants are summarized below; the questions which they raise are so vast and are in such different fields that even a preliminary discussion of their significance must be a cooperative, long-time program.

Jonathan Sauer has contributed the following note concerning the locality where the ears were collected:

"Chiuchiu is an Indian village on the Rio Loa above Calama. It is an irrigated oasis within the approximately rainless desert, the green valley land surrounded by completely barren plains. The altitude is slightly over 2500 meters, and the latitude 22° South. The site is subject to occasional cold winds blowing across near-by snowy mountains. We saw three kinds of maize at the village, the most largely produced being a yellow flint which is also popped. Flint and pop corns are not clearly differentiated in use, name, or perhaps even as to philogeny. They are commonly lumped by the native name *morocho*. In addition, there was a markedly smaller white *morocho* preferred for popping purposes. This is the sample used by Dr. Anderson in the present study. The third local corn was a white, plump-grained flour corn."

The original collection by Sauer and Sauer consisted of two ears which were essentially similar. One of them is illustrated, approximately natural size, in pl. 18. Measurements on the ear and on the plants grown from the seed are presented in table 1. Diagrams of internode patterns are shown in fig. 1. The ears were small,

TABLE I

MEASUREMENTS OF MAIZE FROM THE RIO LOA

Ear No.	Midcob width	Midear width	Row No.	Shank diam.	Cob color	Leaf width	Leaf length	Plant height	Kernel width
1	1.5 cm.	2.8 cm.	20	6 mm.	red	10 cm.	60 cm.	11 dm.	4 mm.
2	1.1 cm.	2.6 cm.	16	5 mm.	white	8 cm.	60 cm.	9 dm.	4 mm.

with slender cobs, the latter being less indurated than is common in modern maize. They were rounded and tapered toward both ends. The small kernels were so irregularly set that the rows (which are apparently arranged spirally) were difficult to count. As in many South American varieties, the kernels were so lightly attached to the cob that they fell off when the cob was handled. Each of the ears was segregating for endosperm color and showed some white and some light yellow grains. Ear No. 1 had a red cob and No. 2 a white one. Cross-pollinations with tester stocks supplied by E. G. Anderson indicated that they were of the genetic

composition *rrccPrPr*. The kernels were flinty and were rounded at the apex.

Seed from cob No. 1 was planted in early May and matured its tassels in 2½ months. Seed from cob No. 2 was planted in late July, and the plants shed their first pollen in exactly 60 days. This was a much shorter season than any of our other collections from South America. Internode diagrams of five plants are presented in fig. 1. As compared with our other collections, the plants from the Rio Loa are outstanding by the constancy of their internode length and the shortness of the internode below the tassel. On the one hand, they did not have the series of gradually increasing short internodes at the base of the plant; on the other, the central internodes were shorter and less variable.

The leaves were short, wide, and pointed, and were unusual in color and texture. They were very dark green and seemed thicker, smoother, and more flexible to the touch than do ordinary maize leaves. There was no pronounced channel in the middle of the leaves as in North American maize, and the mid-rib scarcely protruded from the under surface of the leaf.

The anthocyanin coloration of the sheath was similar to that of our high-altitude collections from Peru and Ecuador but was more extreme. It was not noticeable in young plants but developed rapidly just before the tassels appeared, starting on the back of each sheath and spreading out from this center. It was a dark brownish red and was deposited between the veins of the sheath. When fully developed it gave the appearance of dark green veins running across a purple-brown background. The color was highly and evenly developed on the back of the sheath and faded out towards the margin so that there was almost no color in the marginal centimeter. Dr. L. J. Stadler informs me that both of these features (avoidance of the margin and interveinal color deposition) are usually indicative of a "strong" allele of *B* and a weak allele of *R*.

In our cultures the plants bore from two to four ears with long narrow blade-like appendages on the outer husks. The development of color in the husks was similar to that in the leaves.

As the plants began to tassel one of their most striking features was the one-sided arrangement of about half of them. On these plants the blades of the upper two or three leaves were displaced so that they were immediately above one another and formed a sort of spathe for the tassel (the male inflorescence) when it first appeared. This peculiar arrangement was first described by Collins ('09) as occurring in some of the Waxy maize from China and Burma and has been supposed to be unique in these Oriental varieties. It is well illustrated in Collins' plate in which the plants look very much like some of ours except that ours have broader leaves. As the plants developed they gradually grew out of this peculiar position, and at maturity almost no indication of the one-sided arrangement was left. So far as we know it has not previously been reported for any New World varieties of maize. However, in our own cultures an approach to this condition is sometimes seen in the peculiar high-altitude varieties from Peru and Ecuador.

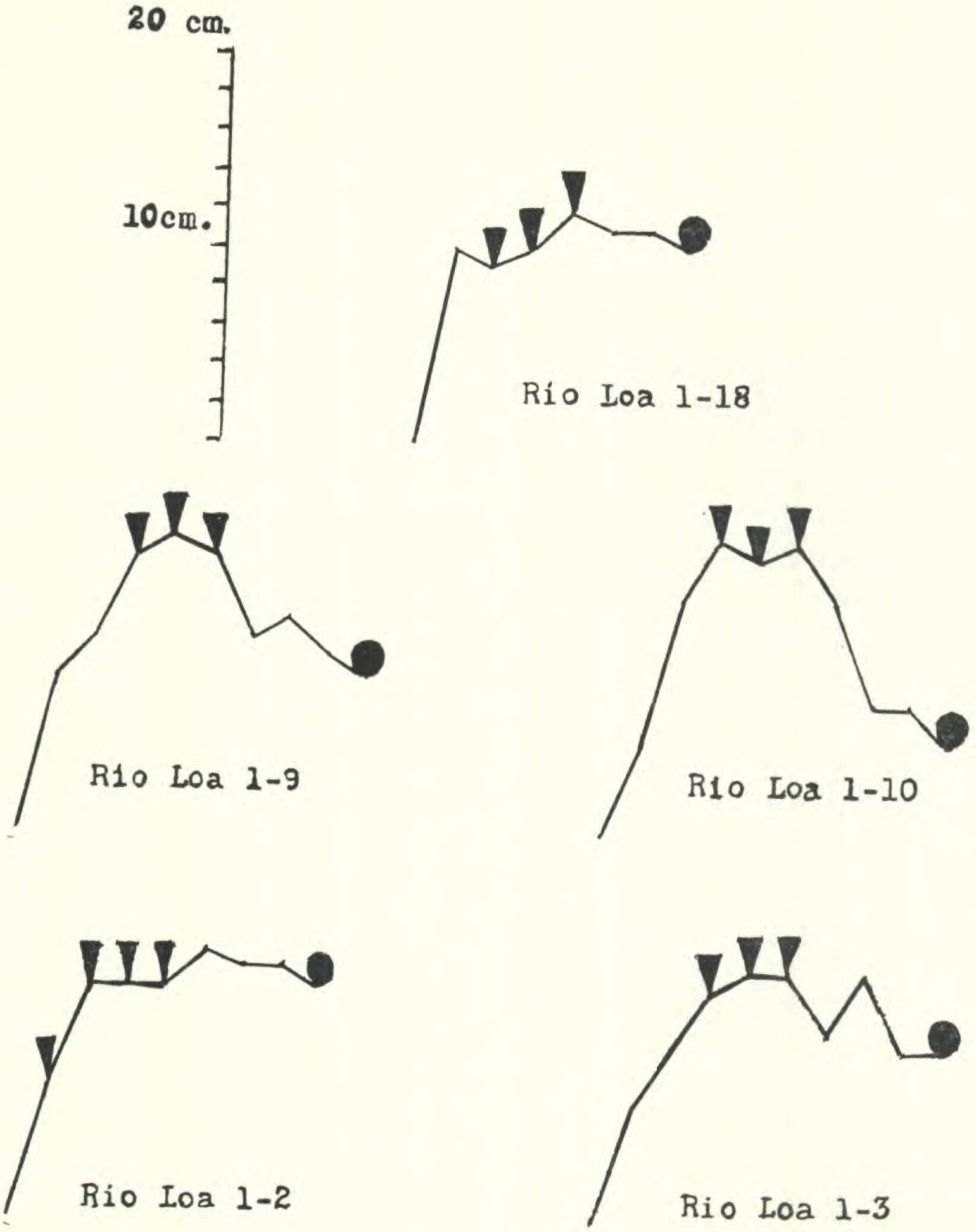

Fig. 1. Internode diagrams of five plants of Rio Loa–1 grown in the experimental fields of the California Institute of Technology at Arcadia, Calif. In each figure the vertical scale represents height in centimeters; the horizontal scale, successive internodes; triangles, ears; and circles, tassels.

The tassels were a dark green throughout, varying from plant to plant in the extent to which a dull dark red was deposited on the glumes, all of which had a bar of dark red at the base. The glumes were small, the upper spikelet was pedicelled, though the length of the pedicel was not as long as in many South American varieties. Several of the plants were sterile, and whether this was due to the change in environment or a segregating gene we have as yet no means of knowing. The plants were segregating for anther and silk color. In some both silk and anthers were pure green; in the remainder they were dilute sun-red.

Pollen mother cells were examined cytologically by means of aceto-carmine smears. They were knobless at pachytene with the exception of chromosome No. 6, which showed a small knob adjacent to the organizing body.

Comparisons with Other Varieties.—The Rio Loa maize as described above was more or less like much of the high-altitude maize of South America in its broad leaves, its low knob number, its tassel characters, and its rounded ears with irregular rows and easily detached kernels. For comparison we had living plants from Peru and Ecuador and an unpublished summary of Bolivian maize prepared by Dr. Hugh C. Cutler. In other characters it is more unique and bears a close resemblance only to certain Oriental varieties and to early prehistoric ears from South America. Contrary to general belief, maize is very extensively grown in certain parts of the Oriental tropics (Heyne, '27; Van Gorkom, '13; Collins, '09) as, for instance, Java, Madura, Burma, and South China. For exact comparisons there are available only the general statements in the literature, Collins' excellent detailed report on a more or less mixed collection from China, and the inbred descendants of this original importation. Seeds of the latter were kindly supplied by J. H. Kempton, then of the U. S. Department of Agriculture. From this material we know that the maize from the Rio Loa resembles the Oriental varieties in its small cob, small seeds, early season, dark green leaves, and in its peculiar habit of forming a spathe over the developing tassel.

Of the prehistoric material, only the ears are available for comparison since they are hundreds if not thousands of years old, and since maize seeds never retain their viability more than a decade or two at the most. The prehistoric material was made available through the courtesy of Professor Alfred Kroeber and the Museum of Anthropology of the University of California. There was also a single collection made by Professor Carl Sauer which was of particular interest since it was obtained from an ancient graveyard only a short distance from the modern maize field in which he found the maize described above.

Distinctive ears of the prehistoric collections are illustrated in pl. 18. It will be seen that the early Nazca material agrees with the ears from the Rio Loa in being small-grained, small-cobbed, irregular-rowed and appressed. All of these ears are associated with the culture designated by archaeologists as "early Nazca." Not until later cultures did larger grains and straighter rows make their appearance (pl. 18, fig. 5). While the ears from the Rio Loa are not identical with the prehistoric collections, they resemble them much more closely than do any of the other ears in our collection, or any that we have seen.

Discussion.—While it has long been known in the Occident that maize was of considerable antiquity in the Orient (see Laufer for a complete discussion) the published evidence could lead only to the conclusion that *Zea Mays* originated in the New World and that it was post-Columbian in the Orient (Mangelsdorf and Reeves, '39). When, however, we no longer content ourselves with cataloguing any kind of maize merely as *Zea Mays* (Anderson and Cutler, '42), it becomes

necessary to re-examine this evidence more precisely. The facts reported above demonstrate that a peculiar strain of maize from a remote and isolated Chilean oasis is, on the one hand, very similar to early prehistoric maize of that same region and, on the other, to certain Oriental varieties. This suggests very strongly a pre-Columbian transfer of maize between the Orient and western South America. From the evidence at present available we have no means of knowing whether it might have originated in the Orient and then spread to South America, there to continue its development as outlined by Mangelsdorf and Reeves ('39) or whether it may have originated in South America and spread in the other direction. All that we know for certain is that a primitive type of maize from western South America is more like Oriental maize in several of its distinctive characteristics than are any of the more commonly cultivated races of that polymorphic species.

It is imperative therefore that the entire problem be re-examined in the light of this evidence and that in particular the small-grained, small-cobbed "pearl Maize" of the Orient be exhaustively compared with living and prehistoric American varieties. Not until extensive collections have been made in Upper India, Burma, and the Dutch East Indies will we be in a position to discuss the question intelligently. It may be pointed out in passing that this region is one of the chief centers of diversity of the Maydeae (Henrard, '31), the group of grasses to which *Zea* belongs. Furthermore, if we follow Mangelsdorf and Reeves ('39) in excepting the genus *Euchlaena* as a comparatively recent artifact, all the Oriental Maydeae agree with *Zea* in having chromosome numbers based on 5 or 10 while the New World Maydeae have a base number of 18.

Summary.—A variety of maize collected from a remote and isolated agricultural community in northern Chile is very similar to the maize of the prehistoric Nazca culture of that same area and adjacent Peru. If not identical with Nazca maize it resembles it more closely than do other varieties in our collections of North and South American maize. In a number of distinctive and peculiar characters it is also more like certain Oriental varieties than anything else in our collections. These facts reopen the entire question of Oriental vs. Occidental origins of *Zea Mays*. Before the problem can be intelligently discussed, definitive collections of maize must be assembled from southern China, Burma, northern India, and the Dutch East Indies.

BIBLIOGRAPHY

Anderson, Edgar, and Hugh C. Cutler. (1942). Races of Zea Mays; I. Their recognition and classification. Ann. Mo. Bot. Gard. **29**:69-88.

Collins, G. N. (1909). A new type of Indian corn from China. U. S. Dept. Agr., Bur. Pl. Ind. Bull. 161:1-30.

Henrard, J. T. (1931). A contribution to the knowledge of the Indian Maydeae. Meded. Rijks Herb. **67**:1-17.

Heyne, K. (1927). De nuttige planten van nederlandsch Indie. p. 148. Buitenzorg.

Laufer, B. (1907). The introduction of maize into eastern Asia. Proc. 15th Int. Congr. Americanists 1:223-257.

Mangelsdorf, P. C., and R. G. Reeves. (1939). The origin of Indian corn and its relatives. Tex. Agr. Exp. Sta. Bull. 574: 315 pp.

Van Gorkom, K. W. (1913). Oost-indische cultures. part III, p. 254. Amsterdam.

EXPLANATION OF PLATE

PLATE 18

Figs. 1–5. Rio Loa maize compared with prehistoric South American ears. All approximately natural size. Photographs courtesy of the Museum of Anthropology of the University of California.

Fig. 1. Original ear (No. 1) collected by Sauer and Sauer.

Figs. 2–4. Three ears (No. 171037) collected at Nazca, Peru, by Professor A. L. Kroeber.

Fig. 5. Prehistoric ear from a later period (Late Inca) to show differences. No. 168804 (courtesy of the Field Museum) collected at Lima Valley (Armatambo), Peru, by Professor A. L. Kroeber. Note the larger cob, larger kernels, and straighter rows.

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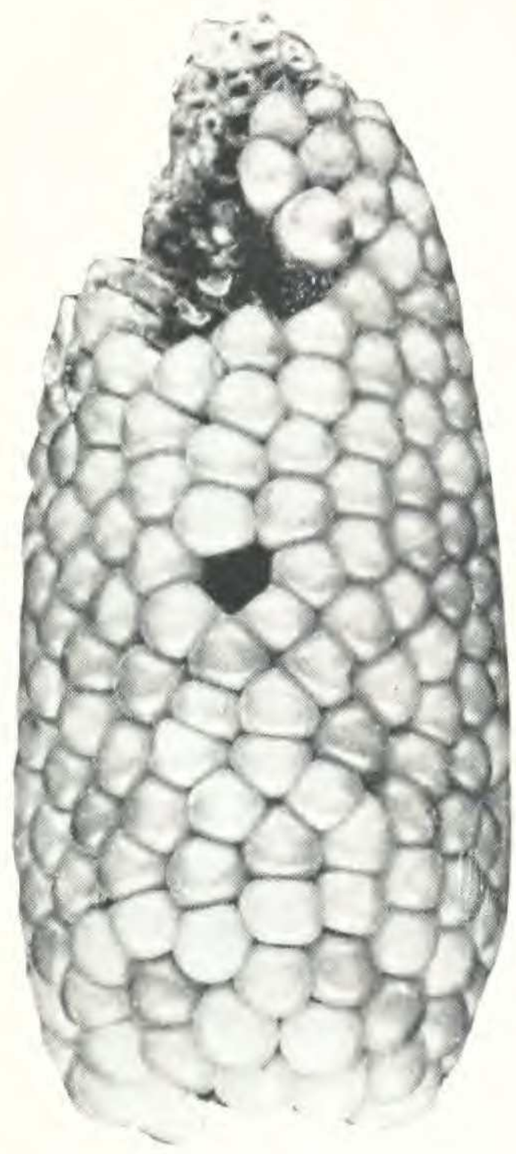

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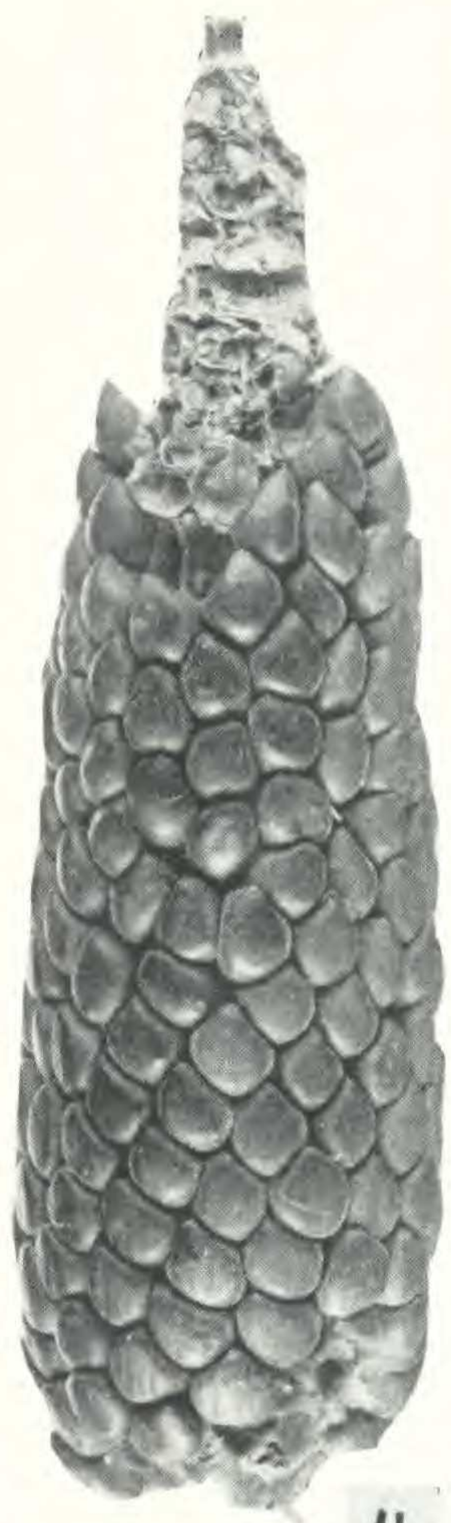

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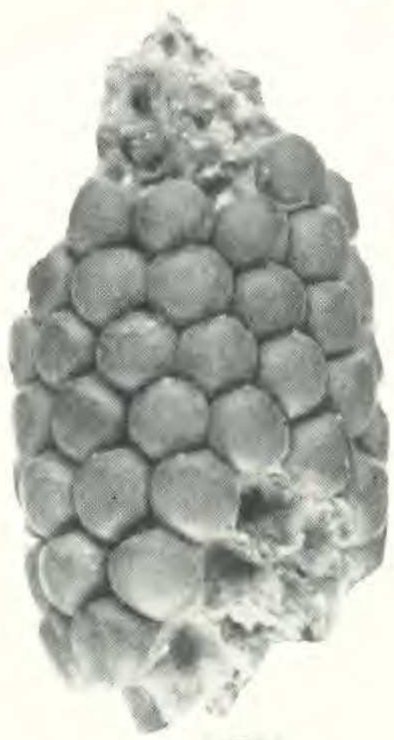

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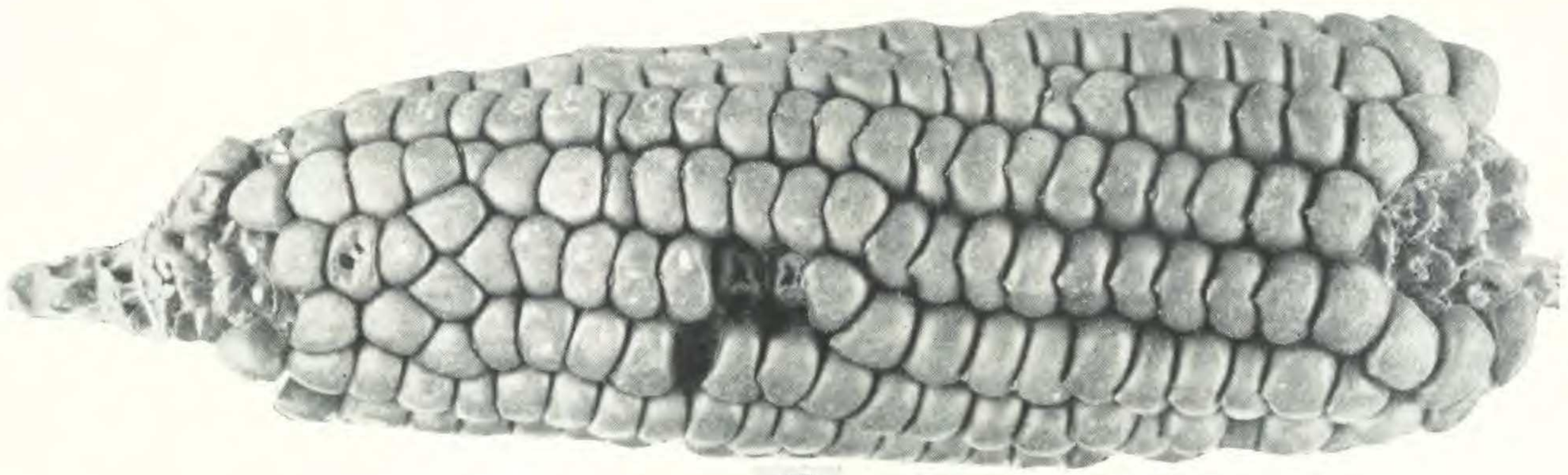

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